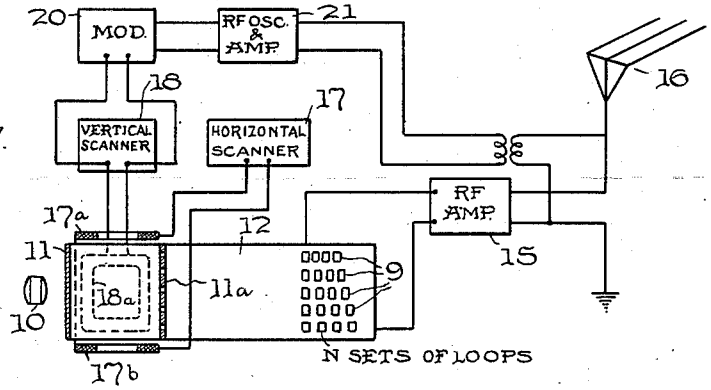
Jan. 29, 1946. P. H. CRAIG 2,393,890

TELEVISION SYSTEM

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Fig. 1.



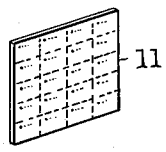


Fig. 1a.

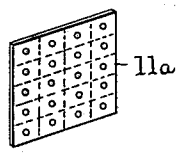
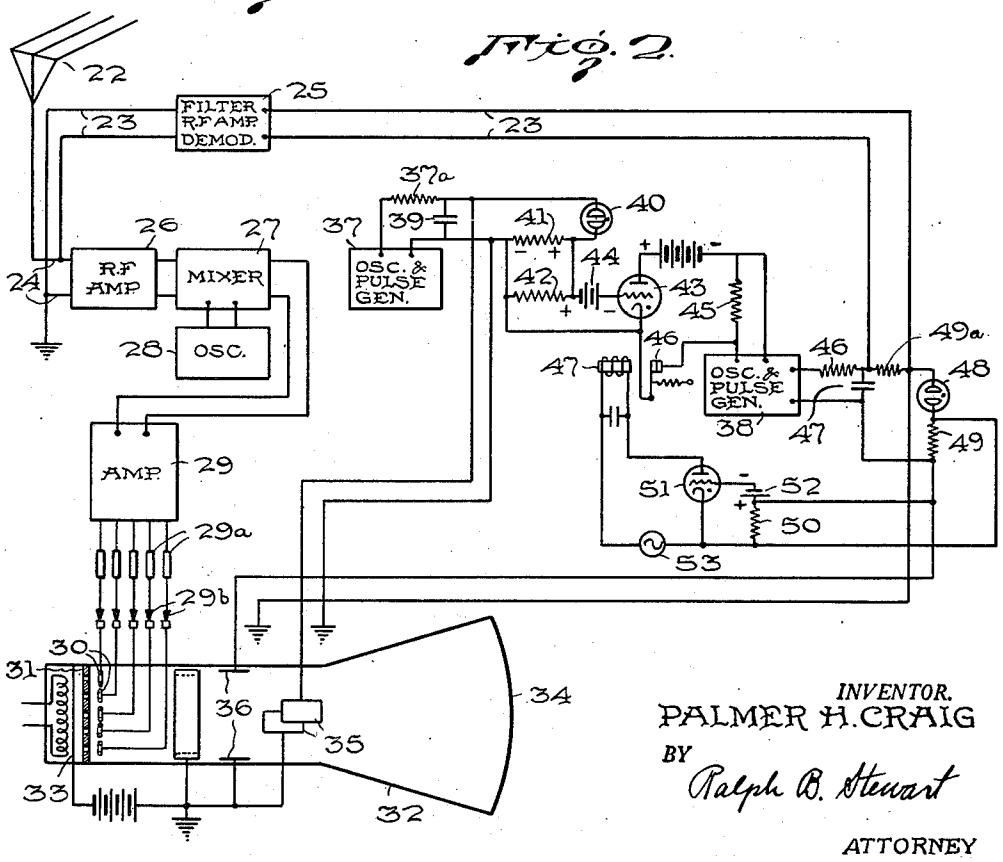


Fig. 1b.

Fig. 2.



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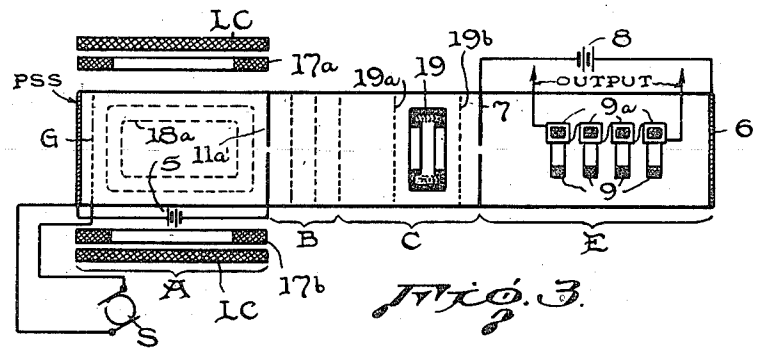


Fig. 3.

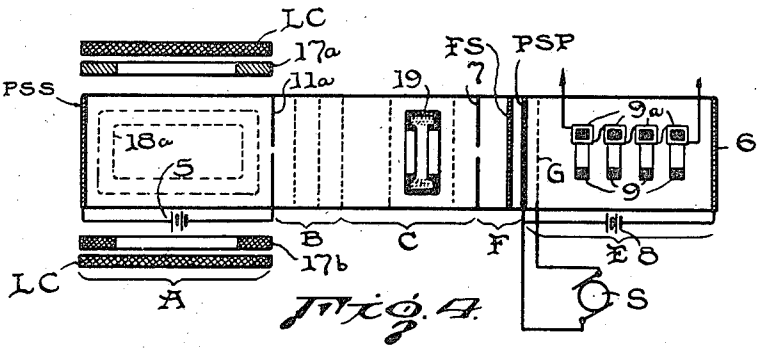


Fig. 4.

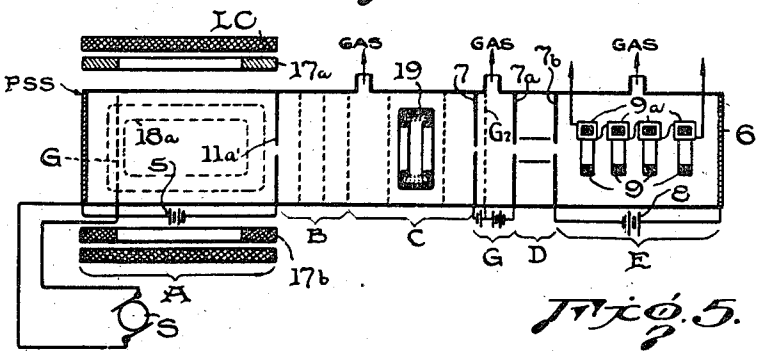


Fig. 5.

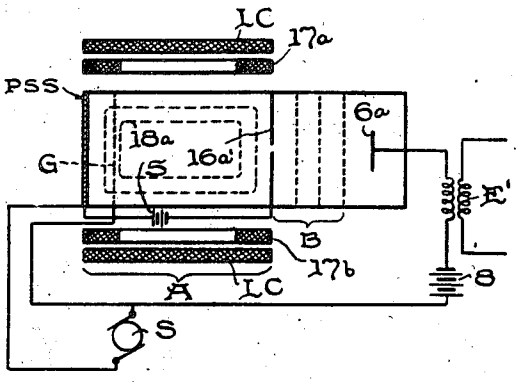


Fig. 6.

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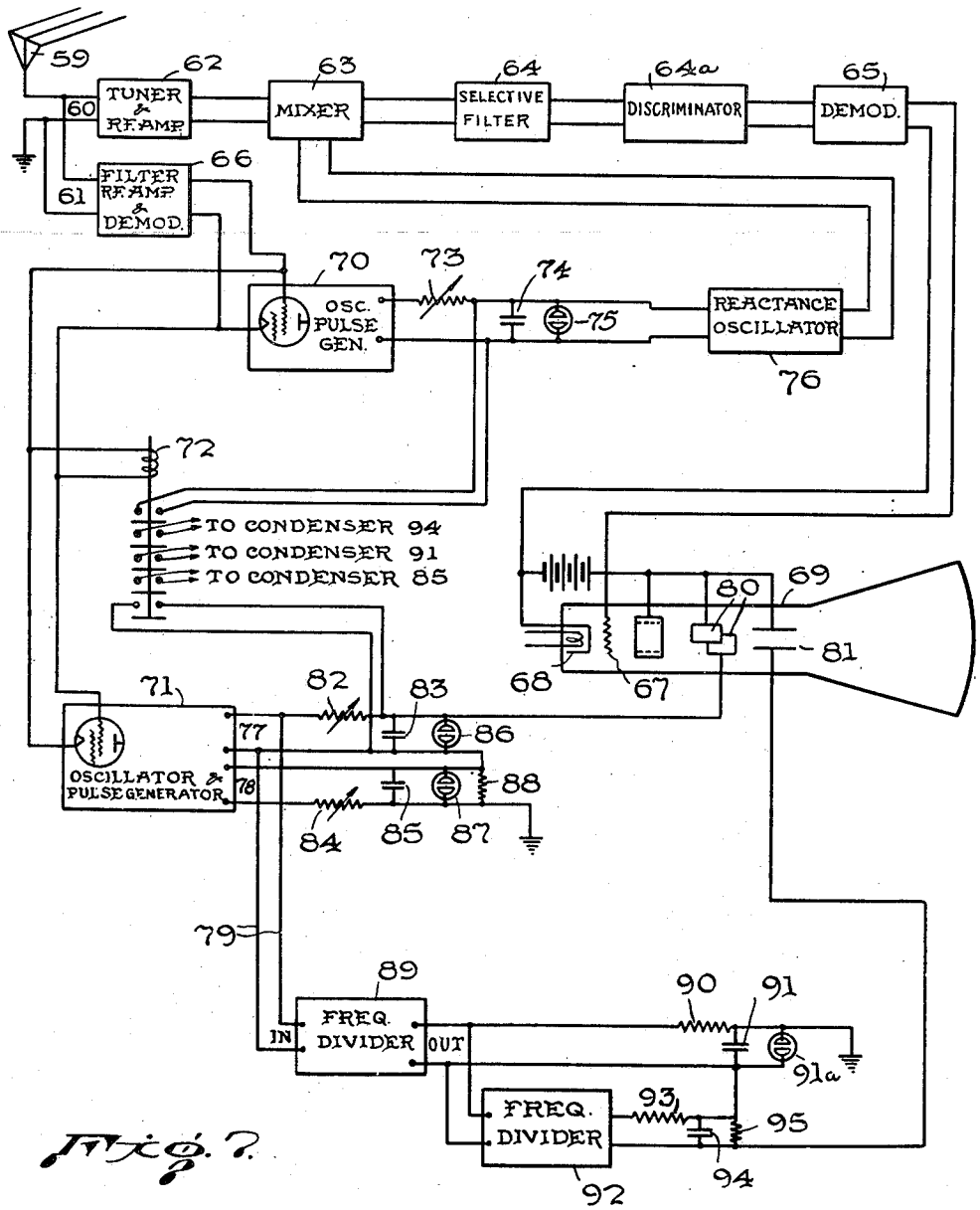


Fig. 7.

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UNITED STATES PATENT OFFICE

2,393,890

TELEVISION SYSTEM

Palmer H. Craig, Gainesville, Fla., assignor to Invex Corporation, a corporation of New York

Application February 18, 1944, Serial No. 522,931

24 Claims. (Cl. 178—6.8)

This invention relates to a television system embodying in modified form the new method or principle of operation disclosed in my copending application for Television system, Serial No. 459,705, filed May 25, 1943. In my prior system the transmitter derives a different frequency from each elementary image area, and transmits all the frequencies simultaneously in the form of a complex wave representing the whole image. In the present system a single frequency is derived in sucession from each area of a group of elementary areas rather than from a single area, each group produces a different frequency, and the frequencies derived from the groups are transmitted as a series of complex waves.

An object of the invention is therefore to so limit the sideband width required for television image transmission as to provide the advantages of longer carrier wave lengths and extended geographic coverage characteristic of systems using the principle of operation disclosed in my above identified prior application.

A specific object of the invention is to simplify the design of the filter used in the receiver to permit reduction of the Q of the filter to values such that the band pass width of the filter may be of the order of a large number of cycles instead of a small number of cycles or even a fraction of a cycle, and thereby to avoid the necessity for suppressing oscillations which continue for a finite time after the exciting energy is removed, a condition which may be present in the extremely high-Q crystal filter of my earlier system.

Other specific objects of my invention are to simplify in various ways the design and method of manufacture of the transmitter tube. The permissible size of the aperture of the magnetic pickup loops is increased and the number of groups of pickup loops is reduced. Other modifications will appear as the description of the invention proceeds.

Briefly, the invention comprises a television method and system and in particular a transmission tube as part of the system, in which the image area is analyzed by simultaneously scanning a plurality of sections of the image, deriving electronically from successive elementary areas of each section waves of a frequency characteristic of that section, and transmitting the different frequencies from the different sections simultaneously. Thus one complete picture frame is transmitted by simultaneously transmitting a plurality of partial frames each on its characteristic frequency. At the receiver the complex wave is separated into its component frequencies and the varying amplitude of each component is used to control the reproduction of its image section, the whole picture being synthesized from the several reproduced image sections.

If the image is considered to be divided into N image sections, each of which comprises P elementary areas, then transmission is effected over a band comprising N principal frequencies instead of the N x P different frequencies which would be required by the system of my prior application. It is obvious that the principal component frequencies in the present system may therefore be more widely separated without extending the band width unduly. Accordingly the extremely sharply tuned filters used in the receiver of my prior application are unnecessary in this modified system of my invention.

A single transmitting tube is designed, according to my invention, to provide the required scanning in multiples of the elementary areas that make up the complete image. For this purpose the tube is subdivided into N smaller sections, the sections being mechanically identical except as the different frequencies generated require different spacings of the pickup loops. The photosensitive screen upon which the complete image is projected for transmission may be considered likewise to be subdivided into N sections, and a plate provided with N apertures is arranged between the photosensitive screen and the pickup loops so that electrons from N elementary areas are permitted to pass through the plate at any one instant. The scanning may be carried out in known manners by use of a fixed axial magnetic field plus variable mutually perpendicular magnetic fields, but a novel effect is obtained by associating the single set of scanning coils with the plate having N apertures so that N sections of the screen may be scanned simultaneously. That is, each aperture scans its own image section and N partial frames are transmitted simultaneously during the same time interval.

In order to increase the effectiveness of the electron action within the transmitting tube, electron multipliers and electron concentrating and focusing means, themselves well known in the art, will normally be incorporated into the tube structure. A number of different tubes designed to produce the type of operation required for my novel system are illustrated diagrammatically in the annexed drawings. Since the N sections of the tube are generally similar, a detailed description of a single section will suffice.

On the drawings,

Figures 1 and 2 represent largely in block dia-

gram form the transmitter and receiver of a television system according to my invention utilizing a novel multiple-section transmitter tube to derive and simultaneously transmit a plurality of radio frequencies representative of the television image to be transmitted.

Figure 1*a* represents schematically a common photo-sensitive screen cathode for the multiple sections of the transmitter tube.

Figure 1*b* represents a common apertured scanning plate for the transmitter tube.

Figures 3, 4, 5 and 6 are diagrammatic representations of various types of transmitter tube which may be used in the television system of my invention.

Figure 7 represents an alternative receiving system in which a single filter and a single-section receiver tube replace the N filters and receiver tube of N sections shown in Figure 2. For this modification a special scanning apparatus, as shown, is required.

In Figure 1, 10 represents the image producing apparatus by which the image to be transmitted at any instant is projected upon a photosensitive surface 11 at one end of a transmitter tube 12. This tube is a multiple tube made up of N sections where N is the number of image sections that are simultaneously scanned. N is also the number of principal components of different frequency which are transmitted simultaneously as a complex wave, but other components may also be present.

The sections or tube elements of which tube 12 is composed may be based on any one of the forms illustrated diagrammatically in Figures 3, 4, 5 and 6. Whichever type of tube section is used, tube 12 will include a photosensitive screen which may be considered as divided into N similar areas as indicated by the twenty areas bounded by the dotted lines in Figure 1*a*, and an apertured scanning plate 11*a* having N suitably arranged apertures, represented diagrammatically in Figure 1*b*. If the form in Figure 3, Figure 4 or Figure 5 is used, N sets of equally spaced magnetic pickup loops will be arranged at the other end of the tube 12 in line with the respective apertures of the scanning plate. For example, for the tube arrangement shown in Figures 1, 1*a* and 1*b* there would be twenty sets of pick-up loops. The sets of loops and the individual loops of each set are all connected in series with one another to a radio frequency amplifier 15 and transmitting antenna 16. If desired, the series connected loops may form a band-pass filter, with the necessary capacitances properly disposed in the regular way. Or, a series of such band-pass filters may be provided by bringing out connections from a plurality of points of the series arrangement of loops so that condensers may be connected in well-known ways to form standard types of band-pass filters.

Scanning means for the multiple tube 12 may be of usual construction such as a pair of horizontal deflecting coils 17*a* and 17*b* supplied from generator 17, and a pair of vertical deflecting coils 18*a* and 18*b* supplied from generator 18. The coil for establishing the usual longitudinal field is not shown in Figure 1, but is shown in section at LC in Figures 3 to 6. Electrostatic deflecting plates or electromagnetic deflecting coils may be used, as preferred. In the drawings of the tube sections in Figures 3, 4, 5 and 6 these deflecting coils are represented as if they encircled the individual tube sections but it will be understood that this showing is merely for convenience and that a single set of scanning coils may suffice for all N sections of tube 12 as shown in Figure 1.

Referring now to Figures 3, 4, 5 and 6, it will be clear that these figures do not show the actual construction of the transmitter tube 12 but merely indicate the basic construction of one tube section or tube element, and illustrate how high frequency currents derived from electronic surges released by a photosensitive cathode are produced in a scanner-type electronic tube.

In Figure 3 electrons are released from photosensitive screen PSS in variable amounts depending on the extent of illumination of each elementary area, and are caused to flow intermittently under the influence of a high frequency alternating voltage applied from source S to grid G which is parallel to and close to screen cathode PSS which corresponds to one sectional area of cathode 11 in Figure 1. The high frequency on grid G is normally but not always necessarily synchronized to the frequency induced in the magnetic pickup loops.

The P elementary image areas into which the screen PSS is subdivided are scanned in succession by the scanning coils about the tube, and electron surges from the P areas pass in succession through the aperture in the scanning plate 11*a'* which divides region A of the tube element from region B. A suitable source represented by battery 5 maintains plate 11*a'* at a positive potential with respect to cathode PSS. The intermittent electronic charge is multiplied by some type of electron multiplier such as the mesh multiplier consisting of electron active grids indicated by the dotted lines in region B and maintained at proper potentials. In region C the electron charge is focused into a narrow parallel stream of electrons by a combination of a magnetic lens 19 and an electrostatic lens 19*a*—19*b* which may be of known construction. The intermittent stream of electrons then passes into region E and through the magnetic pickup loops. The loops are formed of ring shaped magnetic cores 9 having coils 9*a* wound thereon, the coils being connected in series. In each pick-up coil or set of coils an alternating E. M. F. is induced of amplitude and wave shape depending upon the velocity of the electronic charge, the quantity of the charge, its distribution and the dimensions of the magnetic loops. The frequency of the waves will depend on the spacing of the loops (their distance apart) and the velocity of the electron stream.

The magnetic pickup loops or coils are mounted on closed cores having high permeability at high frequencies. They are spaced in accordance with the principle disclosed in my prior application, but in the present case only one set of loops is needed for the whole tube element since electrons from only one elementary area get through at a time. Because of this the loops can be large enough to be easily constructed. The velocity of the electron stream is controlled by the mobility of the electrons in a gas at low pressure, and by the potential gradient in the region of the loops. The whole tube is therefore filled with gas at a low pressure, and the desired potential gradient is established by a potential source represented by battery 8 connected between aperture plate 7 and an end plate 6. The electrons in this gas must be kept at a velocity below that causing gaseous discharge in any part of the tube. This may limit to some extent the efficiency of the mesh multiplier in region B.

The tube element in Figure 4 is similar in most respects to that in Figure 3 with region F added. Region F is separated from region E by a double wall consisting of a fluorescent screen FS and a photosensitive screen PSP. The grid G controlling the surges of electrons is now placed in region E instead of region A, and potential source 8 is connected between PSP and end plate 6. Gas at low pressure is introduced into region E to control the electron velocity, and is confined to region E, the rest of the tube element being evacuated. Upon entering region F after passage through regions A, B and C the electron stream bombards screen FS causing it to emit light. Light incident on screen PSP causes the emission of electrons from the photosensitive screen PSP. The electron stream passes through grid G intermittently in rhythm with the high frequency alternating voltage applied to the grid and penetrates the loops in E. This electron stream will be proportional to the rate of emission of electrons from the elementary areas of the photosensitive screen in region A of the tube element.

The tube element in Figure 5 is basically similar to that in Figures 3 and 4, but regions G' and D have been added. Positive ions are used instead of electrons to induce the E. M. F. in the magnetic pickup loops. A means is provided in region G to produce these ions in quantities proportional to the electrons emitted from the photo-sensitive screen in region A. The electrons pass through regions A, B and C as in Figures 2 and 3. In region G they are given the necessary velocity by proper potential applied to a grid G_2 to ionize the gas in this region. The ions produced in G are then given a definite velocity by focusing and selection means of known type diagrammatically represented in region D. The ion stream enters region E and passes through the magnetic pickup loops, the velocity depending on the mobility of the ions in the gas present at a very low pressure, and the potential gradient in the region established by source 8. The gas is allowed to flow slowly into region G and is continually pumped from the rest of the tube element. This allows a gas pressure in region G large enough for efficient ionization of the gas molecules, but reduces the gas pressure in the rest of the tube to a much lower value in keeping with the requirements for regions A, B, C and E.

The tube element shown in Figure 6 is similar to the other types as to regions A and B. Region E, however, contains a collector plate 6*a* and a transformer E' or some other type of voltage amplifier. The E. M. F. induced in E' will have a frequency equal to that applied to the grid G and an amplitude and a wave shape depending on the number of electrons leaving the photosensitive screen PSS and their distribution in the beam as grid G allows them to pass. The tube element is evacuated.

The four types of tube elements are designed to operate in groups of N tube elements of any one type, to form one transmitter tube 12 (Fig. 1) with a single photosensitive screen cathode 11, a single N-apertured scanning plate 11*a* and a single set of deflecting coils (or plates) 17*a*—17*b* and 18*a*—18*b* supplied with appropriate horizontal and vertical deflecting voltages. Similarly a common set of electron multipliers and electron focusing means which are partly common and partly individual to the tube elements may be utilized in tube 12. However, N sets of magnetic pickup loops with different loop spacings for each set or different gas pressures are required where pickup loops are used to produce the N different frequencies that must be transmitted. With the magnetic pickups of all the tube elements connected in series there will be induced in the conductors leading to R. F. amplifier 15 a complex wave constituting the sum of the electromagnetic forces induced in each of the magnetic pickups. There will be N of these E. M. F.'s, each of a frequency differing from any other and so spaced that the total N frequencies do not exceed the bandwidth desired, for example 50 kc. Each tube element will be identified by its characteristic frequency—that frequency induced in its pickup loops. This frequency will be the same for each elementary area in the tube element.

If desired, a single magnetic pickup loop may be used and in this case the shape and frequency of the E. M. F. induced in it will depend on the velocity of the electron charge and the frequency of the synchronized alternating voltage applied to the grid. The shape and amplitude of the induced E. M. F. will in this case also depend on the distribution and quantity of the charge as well as its velocity.

The frequency applied to the grid from source S in each of the four forms of tube element is normally, but in some cases not necessarily, synchronized to the frequency induced in the pickup loop or loops. The source of synchronized high frequency may be a circuit connected from the tube output to the grid G by inductive or capacitative coupling, this circuit comprising a phase shifter and square wave (or other wave shape) generator of known types. In this way the high frequency derived from the magnetic pickup loops is used to control the frequency of the electron surges from the photosensitive cathode of the tube element.

To one of the scanning systems, horizontal or vertical, of the transmitting tube, and preferably to the latter (as shown) because of its slower operation, is connected modulator tube 20 which is connected in turn to R. F. oscillator and amplifier 21, thence to transmitting antenna 16. When the modulator 20 is triggered by the maximum voltage of the vertical scanning potential, the R. F. oscillator transmits a plus for synchronizing purposes.

In Fig. 2 the receiver antenna 22 is connected to two main channels 23 and 24, one of which filters out the synchronizing impulse from modulator tube 20 and oscillator 21 of the transmitter and the other of which receives the band of N frequencies and reproduces therefrom an image corresponding to the image projected on screen 11 at the transmitter.

In channel 23 the filter, radio frequency amplifier and demodulator are represented diagrammatically at 25; the output of the demodulator is connected in series in the circuit supplying either vertical or horizontal scanning voltages, according to which transmitter scanning voltage source supplied the synchronizing impulse (illustrated as vertical).

In channel 24, a radio frequency amplifier 26 is connected to a mixer 27 which is also supplied with a fixed beating frequency from oscillator 28. The output of the mixer is connected to amplifier 29, then to a set of N filters and their associated N rectifiers diagrammatically represented at 29*a* and 29*b*, each one of which is connected to one grid of N grids 30 suitably arranged in the cathode ray tube 32 to control the flow of electrons from the indirectly heated cathode 33 through apertured plate 31 to the fluorescent screen 34.

The plate 31 is provided with N apertures arranged to correspond to the apertures in plate 11a, Fig. 1b. In combination with the usual focusing means (not shown) these apertures establish N scanning beams which are individually controlled as to density in accordance with the amplitudes of the N received currents of different frequency, and are collectively controlled by horizontal deflecting plates 35 and vertical deflecting plates 36 to scan each its own section of the fluorescent screen, and thereby to reproduce thereon in proper arrangement the N image sections which make up the complete image.

Scanning control of the N scanning beams of the cathode ray tube is effected by a system of scanning comprising a relatively fast pulse generator 37 and a relatively slow pulse generator 38 which provide scanning voltages in the following manner: Pulse generator 37, of known type, is connected through resistance 37a to condenser 39 which in turn feeds a gaseous discharge tube 40 of the neon lamp or thyratron type in a series with resistor 41. The pulses of the pulse generator 37 are caused to build up charges on the condenser 39 in step by step fashion by use of an R–C circuit of sufficiently long time constant, and these stepped voltages are fed to the horizontal deflecting plates 35. When a predetermined value is reached great enough to carry the scanning beams to the extreme righthand positions of their rows, the tube 40 discharges, returning the voltage on condenser 39 to zero, and thus returning the scanning beams to the extreme left of their horizontal rows. The step by step charging of condenser 39 is then initiated anew.

Resistance 41 is connected across the terminals of a resistance 42 in the grid filament circuit of thyratron tube 43, the grid of which is normally biased negative by battery 44. The plate circuit of tube 43 is completed through a resistance 45 and a pair of normally closed contacts 46 of a relay 47. When tube 40 fires, a voltage produced across resistance 41 is transferred by resistance 42 to the grid circuit of tube 43 and this momentary pulse of voltage neutralizes the normal bias on tube 43 sufficiently to permit this tube also to fire. Discharge through the plate circuit of tube 43 supplies voltage across resistance 45.

A pulse generator 38 which produces relatively slow pulses compared to those from pulse generator 37, derives its plate voltage or B supply from the potential drop across resistance 45. That is, there is no B supply for the vertical pulse generator 38 until tube 43 fires. The pulses are supplied through resistance 46 to condenser 47. The vertical deflecting plates of the cathode ray tube are connected in a circuit across condenser 47 to receive vertical scanning voltages which increase in step by step fashion. A gaseous tube 48 and resistance 49 are connected through resistance 49a across condenser 47 the adjustment being such that when the vertical deflection voltage reaches a predetermined value (corresponding to the bottom of the frame) tube 48 fires. The synchronizing impulses from channel 23 are applied across resistance 49a to facilitate accurate timing of the instant of firing. A resistance 50 connected across resistance 49 serves as a source of neutralizing bias for thyratron tube 51 the grid of which is normally biased negative by battery 52 in series with resistance 50 in the grid circuit. Thus when tube 48 fires a momentary voltage appearing across resistances 49 and 50 renders the grid of tube 51 positive, or less negative, and so permits current to flow in the plate circuit of tube 51. An A. C. source 53, which may supply 60 cycle current, is connected to the energizing coil of relay 47. Discharge of tube 51 momentarily energizes relay 47 to cause momentary opening of contacts 46, thus interrupting the plate circuit of tube 43 and restoring control to its grid. Since tube 51 is fed by alternating current its plate current, the current being reduced to zero at the end of each positive alternation, ceases to flow when the voltage disappears from resistance 49.

The operation of a system comprising Figures 1 and 2 is as follows:

An image projected on the screen of transmitter tube 12 is scanned in N sections, each image section serving to produce electronically a characteristic high frequency the amplitude of which varies in accordance with the illumination of P successively scanned elementary areas of the image section. N such frequencies of varying amplitude are transmitted simultaneously and form a band of frequencies which may have a width of 45 kc., for example the N image sections are scanned simultaneously in a given time interval and the scannings are repeated at a rate sufficient to give the illusion of continuity when the image is reproduced at the receiver.

At the end of each complete frame (made up of N simultaneously transmitted partial frames) a synchronizing impulse is transmitted as a modulation of the frequency of oscillator 21 which frequency will differ from the frequencies generated by tube 12.

At the receiver the synchronizing signal from oscillator 21 is selected by channel 23 and controls synchronization of the receiver scanning with the transmitter scanning in the manner explained hereinbefore. Image transmission signals comprising the N component frequencies generated by tube 12 pass through channel 24 to the mixer 27 where they are reduced in the frequency spectrum by beating against the constant frequency from oscillator 28, making selection easier and the selective filter simpler since successive positioning frequencies are in effect more widely separated after combination with the beating frequency. After suitable amplification the N reduced frequencies are selected out by their respective N selective filters and rectified by their respective N rectifiers for application to the N control grids 30 of receiver tube 32. Each one of these rectified voltages represents the successive values of illumination of the P elementary areas of one image section.

The N scanning beams of the receiver tubes are controlled by their horizontal and vertical deflecting voltages to reproduce the scanned elementary areas of the several transmitter image sections in proper position on the receiver image screen, the reproduced image thus being built up in N simultaneously scanned image sections on the fluorescent screen of tube 32.

As already pointed out, the N filters in the output of amplifier 29 need not be so sharply tuned as are the filters of my prior application, while still providing the necessary selectivity to permit transmission of a high definition television image over a relatively narrow frequency band.

In the modified receiving system of Figure 7 the antenna 59 is connected to two channels 60 and 61. The former comprises tuner and radio frequency amplifier represented at 62, mixer 63, selective filter 64, amplitude discriminator 64a and demodulator 65 the output of which is connected to grid 67 and cathode 68 of cathode ray tube 69.

The amplitude discriminator 64a may be a tube biased so that only amplitudes above a predetermined magnitude will swing the grid bias sufficiently to permit the flow of plate current, thus cutting off received impulse current of magnitude less than that for which the cutoff bias is adjusted, and permitting signals to come through only at the peak of the dip in the attenuation curve. The second channel 61 connects the antenna 59 through filter, radio frequency amplifier and demodulator apparatus 66 to the second grids of two oscillator-pulse-generators 70 and 71 of standard form. A third branch of the demodulator output circuit is connected to relay 72, to facilitate synchronization in a manner that will be explained hereinafter.

The output of oscillator-pulse-generator 70 is connected through variable resistance 73 to the terminals of condenser 74 and of a gaseous discharge tube 75 which may be a neon lamp or a thyratron. The condenser terminals are also connected across the input circuit of a reactance oscillator 76 the output of which feeds into mixer 63. The reactance oscillator is of the type in which a change of grid bias produces a change of frequency. The constants of the circuit connected to the oscillator 76 are adjusted to supply a series of N stepped voltages at a series repetition rate of P times per complete frame, the tube 75 being adjusted to fire at the end of each series of N pulses. Thus the reactance oscillator is caused to supply to the mixer a series of N increasing frequencies, and this cycle of frequency changes is covered P times per frame.

The second oscillator-pulse-generator 71 has its output connected to a plurality of circuits preferably through a double triode (not shown) the output circuits of which are represented at 77 and 78. A circuit 79 branching off from triode output 77 leads to an electronic frequency divider to be described hereinafter.

The outputs 77 and 78 are used to build up scanning voltages for the horizontal deflecting plates 80 of cathode ray tube 69, and for this purpose they include resistance-condenser combinations 82, 83 and 84, 85 respectively. The condensers are connected across gaseous discharge devices 86, 87 respectively, the latter being shunted by a very high resistance 88. The terminals of the two condensers are connected in series in the circuit leading to the horizontal deflecting plates of cathode ray tube 69 so that when voltages are applied to both condensers the sum of the voltages is applied across the deflecting plate 80. The time constant of the resistance-condenser combination 82, 83 is much faster than that of the combination 84, 85 and is adjusted to supply stepped voltages to the horizontal deflecting plates in synchronism with the stepped changes in frequency of reactance oscillator 76, while the time constant of 84, 85 is adjusted to supply an incremental voltage to the horizontal deflecting plates in synchronism with each restoration to its initial value of the cyclically varying frequency of the reactance oscillator.

Output branch 79 of the oscillator-pulse-generator and double triode circuit is connected to the input of an electronic frequency divider diagrammatically represented at 89. This is of the type known in the art as "scale of x counter" where x is any predetermined integer. This device counts a given number of input pulses and then gives an output pulse for each series of x input pulses, where x is any predetermined integer. In the circuit of this invention, it is used to count the desired number of horizontal impulses and then to provide one vertical pulse. The vertical pulses are supplied through resistance 90 to condenser 91 which is connected in the circuit of the vertical deflecting plates 81 of cathode ray tube 69 and is shunted by a gaseous discharge tube 91a. A source of incremental voltages for the plates 81 is provided by a second electronic frequency divider 92 connected across the output of the first frequency divider 89. Frequency divider 92 is adjusted to count the number of vertical scanning voltages required for one traverse of the image area and then to provide an incremental vertical voltage. Its output is connected through resistance 93 to condenser 94 which is shunted by resistance 95. The terminals of condenser 94 are connected in series with condenser 91 in the circuit of vertical deflecting plates 81.

Relay 72 is of a type which will not operate on low amplitude impulses of the order of magnitude of those which energize the two oscillator pulse generators to control the production of scanning voltages. It will however, respond to the strong synchronizing pulse which is received at the end of each complete frame. The relay is provided with a set of normally-open shorting contacts for condensers 74, 83, 85, 91, and 94. Instead of operating the shorting contacts for these condensers by relay 72 directly, these contacts may be closed at the proper instants by a constantly running motor which is maintained at the proper synchronous speed by relay 72.

The operation of the system of Figure 7 is as follows:

Channel 60 selects and transmits through tuner and R. F. amplifier 62 a band of frequencies comprising the N amplitude modulated frequencies generated by transmitter tube 12. By way of example let us consider a definite case, assuming that a carrier band in the region of 10 megacycles with a spread of 0.5 per cent or 50 kilocycles is used for transmission. If the transmitter screen is assumed to be divided into 30 image sections (N=30) and each image section comprises 3000 elementary areas (P=3000) then with a frame repetition frequency of 15 per second, the time of scanning each elementary area at the transmitter is approximately 2.20×10^{-5} seconds, giving a side band due to amplitude modulation of approximately 45 kc.

At the receiver, the band of received frequencies is stepped down in the frequency spectrum by beating it against a variable frequency oscillation supplied from reactance oscillator 76. This reactance oscillator must supply a frequency variable in steps so that during the first time interval of scanning at the transmitter (that is, the time during which N elementary areas are scanned simultaneously) each of the N components of the received complex wave is combined with the required frequency to produce a constant frequency beat that is passed through selective filter 64. During each succeeding time interval the reactance oscillator again picks out successively and in turn all of the N simultaneously transmitted frequency components of the complex wave, the time interval during which a wave of given frequency is passed through selective filter 64 being approximately 0.75×10^{-6} second.

The transmission band of channel 61 includes the frequency of transmitter oscillator 21 which is modulated by a strong impulse from the vertical scanner at the end of each complete frame.

Strong impulses of this frequency operate relay 72 to short the condensers 74, 83, 85, 91 and 94, removing the charge from these condensers and thus aiding sychronization of the frequency variation of the reactance oscillator 76 with the application of scanning voltages to the cathode ray tube 69. The low amplitude pulses from channel 61 control the generation of pulses by fast pulse generator 70 and slow pulse generator 71, the former to control and time the generation of voltages which change the bias of the reactance oscillator 76 to thereby change its frequency at the required rate. The slow pulse generator controls and times the generation of vertical and horizontal scanning voltages supplied to the deflecting plates 80 and 81 of cathode ray tube 69. The single scanning beam of the receiver tube traverses the area of the fluorescent screen 34 at a rate of P times for each complete frame, and during each traverse follows a pattern corresponding to that of the scanning apertures of the plate shown in Figure 1b. The starting point of successive traverses must, of course, shift from one elementary area to the next in the initial image section of the N image sections, and to provide this shift the incremental horizontal and vertical scanning voltages from condensers 85 and 94 respectively are required, in addition to the normal scanning voltages supplied by condensers 83 and 91. Tube 75 clears the voltage from condenser 74 each time the reactance oscillator completes its range of frequency changes. Tubes 86 and 88 clear the horizontal scanning voltages (normal and incremental) from condensers 83 and 85 respectively, the former at the end of each horizontal row and the latter at the end of a complete frame. Tube 91 clears the normal scanning voltage from condenser 71 at the end of each traverse (skeleton frame), and the vertical incremental voltage from condenser 94 is cleared by the shorting contacts of relay 72 at the end of a complete frame. Relay 72 also shorts condensers 74, 83, 85 and 71 at the same instant to maintain proper synchronization with the scanner at the transmitter.

Thus by suitably reproducing successively the N points which are scanned simultaneously at the transmitter, and by traversing the fluorescent screen once for each elementary area in a single image section, repeating the P traverses at a repetition rate sufficiently high to give the illusion of continuity of illumination, the image projected on the photosensitive screen 11 of transmitter tube 12 is reproduced on the fluorescent screen of receiver tube 32 by a single scanning beam.

It is within the scope of my invention to utilize any suitable equivalent piece of apparatus to replace apparatus specifically illustrated herein. For example, the reactance oscillator at the receiver may be replaced by some other type of frequency generator capable of supplying oscillations which vary in the manner required by my invention and which may be suitably synchronized in operation with the scanning apparatus to provide the novel scanning pattern disclosed herein.

What I claim is:

1. In a television system the method of communicating image signals representing an image projected onto a transmitter screen which comprises deriving directly from the light energy of the projected image a plurality of high frequency signal currents of different frequencies representing a corresponding plurality of different sections of the projected image area, each section including a plurality of elementary areas, simultaneously transmitting said signal currents at the derived frequencies to a distant point and reproducing said sections of the projected image at the distant point to form a complete image corresponding to said projected image.

2. In a television system the method of communicating image signals representing an image projected onto a transmitter screen which comprises the step of simultaneously scanning corresponding elementary areas in a plurality of image sections to produce for each image section a signal wave of frequency characteristics of that image section and of amplitude varying in accordance with the illumination of successively scanned elementary areas of said image section.

3. In a television system, a transmitter screen divided into a plurality of sections each section comprising a plurality of elementary areas corresponding in position within the section to elementary areas in each of the other sections, and means for scanning corresponding elementary areas simultaneously in each section of said screen.

4. In a television system, a transmitter screen divided into a plurality of sections each section comprising a plurality of elementary areas corresponding in position within the section to elementary areas in each of the other sections, means for projecting an image on said screen, means for deriving from the image sections projected onto said screen sections a plurality of high frequency currents of frequencies different for each section, scanning means for simultaneously scanning the elementary areas in each section and controlling the amplitude of each high frequency current in accordance with the illumination of the successive elementary areas scanned within each section, means for simultaneously transmitting said plurality of currents, and means for deriving therefrom an image corresponding to the image projected on said screen.

5. In a television system, the combination defined in claim 4 in which said last mentioned means comprises means for receiving said different high frequency currents simultaneously and means for utilizing said different high frequency currents successively to reproduce an image corresponding to the image projected onto the transmitter screen.

6. In a television system, a transmitter screen divided into a plurality of sections each section comprising elementary areas corresponding in position within the section to elementary areas in each of the other sections, means for projecting an image on said screen, means for scanning corresponding elementary areas simultaneously to produce signals of amplitude varying in accordance with the illumination, an image receiving screen, means for simultaneously scanning said receiving screen in sections corresponding to the sections of said transmitter screen to reproduce said transmitter image, and means for synchronizing said transmitter and receiver scanning means.

7. Apparatus for producing image-modulated high frequency currents for a system in which the image to be transmitted is scanned simultaneously in sections, comprising a tube containing a photosensitive screen to receive the image to be transmitted, means for interrupting at high frequency the emission of electrons from said screen, an apertured plate in the paths of said electrons, means for projecting through each ap-

erture of said plate electrons from elementary areas of said screen the projection being successive for elementary areas of a screen section, means for controlling the potential gradients along the paths of said electrons, an atmosphere of ionizable gas for said electron paths and means for inducing in an electrical conductor within said tube currents of high frequencies dependent on said potential gradients and the pressure of said ionizable gas.

8. Apparatus for producing image-modulated high frequency current comprising, in a transmitter tube, a photosensitive screen for receiving the image to be transmitted, a grid located close to said screen, a source of high frequency current connected to said grid; an apertured plate, means for projecting in succession through said apertured plate electrons from elementary image areas of said screen, means for controlling the potential gradient along the path of said electrons to thereby control their velocity, an electrical conductor constituting an output for the tube and means for inducing in said electrical conductor current of frequency dependent on the velocity of said electrons.

9. Apparatus for producing image-modulated high frequency current comprising, in a transmitter tube, a photosensitive screen for receiving the image to be transmitted, an apertured plate, means for projecting in succession through said aperture electrons from successive elementary image areas of said screen, means for controlling the potential gradient along the path of said electrons to thereby control their velocity, an electrical conductor constituting an output for the tube said conductor comprising a plurality of spaced loops mounted on closed magnetic cores of high permeability arranged to encircle the path of said electrons.

10. Apparatus for producing image-modulated high frequency current comprising, in a transmitter tube, a photosensitive screen, a source of high frequency alternating potential connected to a control grid located close to said screen whereby said grid serves to interrupt at high frequency the emission of electrons from said screen, a plurality of spaced loops on annular magnetic cores arranged in line with the emissive area of said screen and means for controlling the velocity of the electrons in their path through said annular magnetic cores.

11. Apparatus for producing image-modulated high frequency current comprising, in a transmitter tube, a photosensitive screen, a source of high frequency alternating potential connected to a control grid located close to said screen whereby said grid serves to interrupt at high frequency the emission of electrons from said screen, a plurality of spaced loops mounted in line with the emissive area of said screen in the path of electrons therefrom, means for supplying ionizable gas in the region of said electron path, and means for controlling the potential gradient along said electron path.

12. Apparatus for producing image-modulated high frequency current comprising, in a transmitter tube, a photosensitive screen, a plurality of current-inducing loops connected in series and arranged at spaced intervals along the path of electrons emitted from said screen, a fluorescent screen arranged behind said photosensitive screen to serve as a source of illumination therefor, a second photosensitive screen for receiving the image to be transmitted and means for scanning said second screen so as to project on said fluorescent screen in succession electrons from the elementary image areas of said second photosensitive screen.

13. The combination defined in claim 12 above and a gaseous filling for the portion of the tube enclosing the first mentioned photosensitive screen and said spaced loops, whereby electrons are projected axially through said loops to produce in said loops high frequency current of amplitude varying in accordance with the variable illumination of said second mentioned fluorescent screen.

14. The combination defined in claim 12 above and means for multiplying and directing the projected electrons so as to intensify the emission from said second photosensitive screen.

15. In a television system, a transmitter comprising means for simultaneously producing from the elementary image areas of an image screen a series of complex waves each of which comprises a band of frequencies having frequency components representative of the illumination of a group of elementary areas of said screen, a cathode ray receiving tube including a fluorescent screen designed to receive an image reproduced from said series of complex waves and receiving apparatus connected between said transmitter and said cathode ray receiving tube comprising means for simultaneously receiving and successively utilizing in said cathode ray receiving tube the frequency components of each complex wave of said series of complex waves to reproduce the transmitted image.

16. The combination defined in the above claim 15 which said means includes a variable frequency oscillation generator and means to vary the frequency of said generator to produce each of a plurality of frequencies differing from said frequency components by a constant frequency, a mixer for combining the received complex waves with the output of said variable oscillation generator to produce thereby successive bands of beat frequencies each having a component of said constant frequency, a filter tuned to said constant frequency and connections from the output of said mixer through said filter to the cathode ray receiving tube.

17. In a television system, a transmitter comprising an image screen and means for producing from an image projected thereon complex waves having principal frequency components each of amplitude varying in accordance with the illumination of the elementary areas of a section of said screen, means for transmitting said frequency components simultaneously as a complex wave, means for receiving and amplifying said complex wave, means for combining said complex wave with a constant frequency oscillation to produce a complex beat wave stepped down in frequency with respect to said transmitted complex wave, a plurality of filters tuned respectively to the principal components of the lowered-frequency complex wave, a cathode ray receiving tube having a plurality of control grids connected one to each of said plurality of filters, and a single scanning means for said tube for reproducing said transmitter image under the joint control of said plurality of grids.

18. In a television system, a transmitter comprising an image screen and means for producing from an image projected thereon complex waves having principal frequency components each of amplitude varying in accordance with the illumination of the elementary image areas of a section of said screen, means for transmitting said fre-

quency components simultaneously as a complex wave, means for periodically transmitting a synchronizing impulse, means for receiving and amplifying said complex wave, means for combining said wave with a constant frequency oscillation to produce complex beat wave stepped down in frequency with respect to said transmitted complex wave, a plurality of filters tuned to the components of the lowered frequency complex wave, a cathode ray receiving tube connected to said filters, scanning means for said tube for simultaneously reproducing from said beat wave components image sections corresponding to the transmitted image sections and means for utilizing said synchronizing impulses to provide joint synchronization of said image sections.

19. In a television system, a transmitter comprising an image screen and means for producing from an image projected thereon complex waves having principal frequency components each of amplitude varying in accordance with the illumination of the elementary image areas of a section of said image screen, means for transmitting said components simultaneously, means for periodically transmitting a synchronizing impulse, means for receiving and amplifying said frequency components, a variable frequency oscillator, means for combining said complex wave with varying frequency from said oscillator to produce a complex beat wave having a component of predetermined constant frequency but of varying amplitude representing in succession the light values of all the elementary image areas of said screen, a filter tuned to said predetermined frequency, a cathode ray receiving tube connected to be energized by said filter, scanning means for said tube, and means for receiving and utilizing said synchronizing impulses to synchronize the frequency variations of said oscillator and the scanning of said cathode ray tube.

20. A television transmission system comprising a transmitter tube containing N tube sections and a photosensitive screen common to said sections for receiving an image to be projected, means in said tube for deriving from the illuminated sections of said screen N electron streams interrupted at N different high frequencies each of which is characteristic of one of the N screen sections and all of which are comprised within a frequency band of the order of 45 megacycles, means for transmitting said band and for receiving it at a distant point and means for reproducing at said distant point from the received frequency band an image corresponding to the image projected on said common transmitter tube screen.

21. Image transmitting apparatus comprising, in combination, a photosensitive cathode for producing an electron image, means for directing electrons from an elementary area of said image along a predetermined path, an inductor element arranged adjacent said path and in inductive relation to the electrons passing along said path, and scanning means for successively directing electrons along said path from different elementary areas of said electron image.

22. Image transmitting apparatus according to claim 21 and including means for periodically interrupting the electrons transmitted along said predetermined path.

23. Image transmitting apparatus comprising, in combination, a photosensitive cathode for producing an electron image, an apertured plate positioned adjacent said cathode, means for directing electrons from an elementary area of said cathode through the aperture of said plate, means for directing the electrons passing through said aperture along a predetermined path, a plurality of spaced inductor elements arranged in inductive relation to the electron stream passing along said predetermined path, and scanning means for successively directing electrons through said aperture from different elementary areas of said cathode.

24. Image transmitting apparatus according to claim 23 and including means for periodically interrupting the stream of electrons transmitted through said aperture.

PALMER H. CRAIG.

CERTIFICATE OF CORRECTION.

Patent No. 2,393,890. January 29, 1946.

PALMER H. CRAIG.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, line 47, for "plus" read --pulse--; page 6, second column, line 13, claim 2, for "characteristics" read --characteristic--; page 7, second column, line 36, claim 16, before the word "which" insert --in--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 16th day of April, A. D. 1946.

Leslie Frazer

(Seal) First Assistant Commissioner of Patents.